Amendments to the Specification:

Please amend the title of the invention by replacing it with the following title:

LED LIGHTING ARRAYS, FIXTURES AND SYSTEMS

Please amend or insert the following paragraphs in the Specification as instructed below.

Replace paragraph [0005] with the following paragraph:

[0005] Conventional theatrical lighting fixtures typically utilize a lamp that radiates white light, which is then filtered in various ways to produce color when colored light is desired. Filtering subtracts certain wavelengths from a beam with a broad spectral power distribution. For example, the conventional "PAR" fixture includes a white light source (lamp) with a parabolic reflector directing light to a lens with gel color filters, and is typically housed in a cylindrical or can configuration. Conventional theatrical lighting fixtures may be automated with motors that are attached to lenses or to rolls of flexible gels (filters) that move in front of the lamp. Occasionally some fixtures are fitted with multiple~~,~~ overlapping rolls of gels or colored lenses. ~~When~~ Using such filters ~~are used~~ in combination~~, this~~ is known as subtractive color mixing and this technique provides a limited range of automated color control. On most fixtures, however, filters are fixed and must be changed manually to alter the color. Manual filter changing can be an expensive and time-consuming process.

Replace paragraph [0007] with the following paragraph:

[0007] A common misunderstanding of human color perception holds that since we distinguish color by using three different kinds of receptor cones in our eyes (a widely understood and proven physiological fact), we therefore perceive only three primary colors of light. The thinking continues toward the mistaken belief that by using a mix of three primary colors of light in various relative intensities, we can precisely duplicate any color in the spectrum.

Replace paragraph [0010] with the following paragraph:

[0010] LED-based lighting fixtures that implement any of these misconceptions produce light that is inadequate for a broad range of effective, primary illumination. RGB fixtures produce colored light with relatively poor saturation across the spectrum, except at red, green, and blue. RGB fixtures illuminate colored objects in an unnatural way, making many colors appear hyper-real or more vivid than under midday sunlight, but also making them appear less differentiated from one another, with a strong tendency to make colored objects appear either ~~more~~ redder, ~~more~~ greener, or ~~more~~ bluer than normal. RGB fixtures exhibit relative luminance levels that are difficult for an average user to predict when mixing colors, because they do not correlate with the relative luminance levels of conventional lamps with filters of similar colors. White light from RGB fixtures appears weak, empty, or grayish to many observers. RGB fixtures often produce an undesirable response on human skin tones, making many flesh colors appear ruddy or slightly greenish or grayish. RGB fixtures have a limited range of CCT values that appear rich, full, and satisfying to the average observer.

Replace paragraph [0018] with the following paragraph:

[0018] Embodiments of the invention include LED arrays~~,~~ and light fixtures wherein the discrete LEDs in the array emit light at one of multiple dominant wavelengths corresponding to at least five different colors within the visible spectrum. Systems based on the LED arrays and light fixtures are also disclosed. Additionally, a method of testing human visual perception is also disclosed.

Insert the following new paragraphs between paragraphs [0029] and [0030].

[0029.1] FIG. 10 is a graphical representation of an area enclosed by plotting the output of each uniquely colored LED from an LED array according to the present invention on a CIE Chromaticity diagram as a point and connecting the points. The area covers approximately 75% of the total area defined within the curve of spectrally pure colors and an alychne of purple colors on the CIE Chromaticity diagram.

[0029.2] FIG. 11 is a graphical representation of an area enclosed by plotting the

output of each uniquely colored LED from an LED array according to the present invention on a CIE Chromaticity diagram as a point and connecting the points. The area covers approximately 85% of the total area defined within the curve of spectrally pure colors and an alychne of purple colors on the CIE Chromaticity diagram.

[0029.3] FIG. 12 is a graphical representation of an area enclosed by plotting the output of each uniquely colored LED from an LED array according to the present invention on a CIE Chromaticity diagram as a point and connecting the points. The area covers approximately 95% of the total area defined within the curve of spectrally pure colors and an alychne of purple colors on the CIE Chromaticity diagram.

Replace paragraph [0032] with the following paragraph:

[0032] It is conventionally known that there are three different kinds of receptor cones in the human eye for stimulation by specific ranges of wavelengths of light. Every wavelength of light has the potential of stimulating each of these cones at a certain level of probability. The three cone types peak in the probability that they will be stimulated at points on the visible spectrum that are roughly equal to blue-violet, green, and yellow, and are identified as short, medium, and long (S, M, and L), respectively. All three are necessary for robust color sensation across the visible spectrum. For example, a 420 nm wavelength of light has a very high probability of stimulating the S-cones in the eye, but only a low probability of stimulating the M-cones, and a very low probability of stimulating the L-cones. ~~This is why a~~A human observer can distinguish it as violet light, because the S-cones in the eye are the most stimulated by it and are therefore sending the strongest signals to the brain.

Replace paragraph [0033] with the following paragraph:

[0033] A 650 nm wavelength of light has a higher probability of stimulating the L-cones than stimulating the M-cones, and a much higher probability of stimulating the L-cones than stimulating the S-cones. It is of no consequence that there are no cones in the eye that peak in their sensitivity at that particular wavelength of light. What matters is that one type of cone is more sensitive to it than the other two. This is enough for the

visual network to identify the light as red. This is the same for all colors of light, *i.e.*, that the sensitivities of the three cone types peak at certain wavelengths is not nearly as important as the fact that all three peak in different places along the visible spectrum and that the sensitivity slopes gradually downward on either side of the peaks, rather than dropping off sharply to zero.

Replace paragraph [0035] with the following paragraph:

[0035] However, there are three cone types in the eye: S-, M-, and L-cones. Thus, the mix of red and green wavelengths that produces the same levels of stimulation from the M- and L-cones as ~~does~~ amber light stimulates the S-cones differently. Amber light stimulates S-cones at a very low probability~~,~~ – almost zero. Green light, on the other hand, stimulates the S-cones with a slightly higher probability. This suggests that the red+green combination will appear less saturated than the pure amber light to an average observer.

Replace paragraph [0036] with the following paragraph:

[0036] It is the existence of these three kinds of cones in the eye, as well as the other receptors and processors within the human visual system (that may or may not be fully understood at this time), that teaches away from the concept ~~of~~ that the so-called "primary colors" ~~that~~ are capable of reproducing any other color within the visible spectrum at any given level of saturation. Every individual wavelength along the entire visible spectrum can be clearly identified and distinguished with relative precision from a substitute that mixes different wavelengths in combination to achieve its approximation. This is why RGB additive color mixing can only produce less saturated substitutions for most colors that are substantially different than red, green, and blue.

Replace paragraph [0041] with the following paragraph:

[0041] Another embodiment of a LED array according to the present invention may include relative luminance values for all LEDs within the LED array operating at full brightness levels, resulting in a composite white-type light that may be plotted on a CIE

Chromaticity diagram within McAdam ellipses that are on or adjacent to the Planckian Locus (which defines the region of color temperatures produced by a black-body radiator) within a predefined correlated color temperature (CCT) range. The predefined CCT range may be between about 1500° K and about 25,000° K according to an embodiment of the present invention. The predefined CCT range may be between about 3000° K and about 10,000° K according to another embodiment of the present invention. In still another embodiment of the present invention, the predefined CCT range may be between about 4500° K and about 7500° K. In yet another embodiment of the present invention, the predefined CCT range may be between about 5500° K and about 6500° K. Of course, other suitable predefined CCT ranges are also considered within the scope of the present invention. In still another embodiment of a LED array according to the present invention, the relative luminance of each LED or group of LEDs in the LED array may comprise a spectral power distribution within 30% normalized mean deviation of a spectral power distribution of midday sunlight~~ having correlated color temperature (CCT) of about 6500°K~~.

Replace paragraph [0042] with the following paragraph:

[0042] Yet another LED array according to the present invention may include a relative luminance of each LED or group of LEDs in the LED array that is consistent with the distribution of spectral power in midday sunlight~~ (at a CCT of approximately 6500°K)~~ in order to facilitate additive color mixing that produces intuitive intensity levels. It is understood that Luxeon brand LEDs by Lumileds, LLC, or any similarly bright LEDs from various manufacturers, may not be available in commercially viable quantities in all desired dominant wavelengths across the visible spectrum. Therefore, LEDs that are available in the dominant wavelengths nearest the desired dominant wavelength and in packages that produce brightness levels consistent with other LEDs in the array may be substituted. Those LEDs or groups of LEDs may consequently have higher relative luminance values, depending upon the distance from the desired dominant wavelength and (if applicable) the distance to the nearest available dominant wavelength on the opposite side of the desired dominant wavelength.

Replace paragraph [0043] with the following paragraph:

[0043] CIE diagrams, CCT, alychne, McAdam ellipses, and Planckian Locus are all concepts and terms well known to one of ordinary skill in the art, and~~,~~ thus~~,~~ will not be further elaborated on herein. A reference providing further detail on colorimetry is Daniel Malacara, "Color Vision and Colorimetry Theory and Applications", SPIE Press, 2002, the contents of which are incorporated herein by reference for all purposes.

Replace paragraph [0045] with the following paragraph:

[0045] Table 1~~,~~ below~~,~~ is a spatial representation of an embodiment of a base mix strip array in accordance with the present invention.

TABLE 1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| B | G | C | I | G | B | C | G |
| A | R | A | A | A | O | A | A |

The base mix strip array may include 16 LEDs spatially arranged as shown in Table 1, where B = blue, G = green, C = cyan, I = royal blue, A = amber, and O = red-orange LEDS. A single unit formed of the 16 LEDs as shown in Table 1 may form a 2x8 micro-strip fixture according to an embodiment of base mix LED array. Each of the seven colors may be controlled by a separate circuit or by a single LED driver circuit with independent control of each LED according to other embodiments of a base mix LED array. According to a specific embodiment of base mix strip array, the LEDs may be mounted in rows within the channels on a finned extrusion, thereby providing adequate heat-dissipating surface area while leaving a flat surface exposed for wall-mounting or other surface mounting of the fixture. One such extrusion is part #XX5052 from Wakefield Thermal Solutions, Inc., 33 Bridge Street, Pelham, NH 03076. Of course, other suitable extrusions, custom-designed housing components, and mounting arrangements for the

LEDs in a fixture that maintain the spatial arrangement of Table 1 are also contemplated within the scope of the present invention.

Replace paragraph [0047] with the following paragraph:

[0047] Table 2~~,~~ below~~,~~ illustrates a variation of the base mix strip array that may be referred to herein as a reverse base mix strip array.

TABLE 2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | A | O | A | A | A | R | A |
| G | C | B | G | I | C | G | B |

where R = red, O = red-orange, A = amber, G = green, C = cyan, B = blue and I = royal blue. Note that the reverse base mix array is the same as the base mix array rotated ~~by~~ 180°.

Replace paragraph [0050] with the following paragraph:

[0050] LEDs for the above-referenced LED arrays may be Luxeon™ LEDs, a 1.2-Watt package of the specified color/wavelength. Luxeon™ LEDs are available from Lumileds Lighting, LLC, 370 West Trimble Road, San Jose, California~~,~~ 95131.

Replace paragraph [0054] with the following paragraph:

[0054] An embodiment of a LED array may be formed of a plurality of LEDs, each LED or group of identically colored LEDs comprising a dominant wavelength within the visible spectrum (400 to 750 nm)~~having overall luminance sufficient to illuminate an object from a distance of at least 24 inches~~. Another embodiment of a LED array may be configured with each LED or group of identically colored LEDs within the LED array for independent control.

Replace paragraph [0057] with the following paragraph:

[0057] Yet another embodiment of a LED array according to the present invention may include a plurality of LEDs comprising at least the following specified colors and falling within 25 nm of an associated dominant wavelength: violet 405 nm, indigo 445 nm, blue 480 nm, cyan 510 nm, green 535 nm, lime 555 nm, yellow-amber 575 nm, orange 600 nm, orange-red 630 nm, and deep red 665 nm. Other embodiments of a LED array consistent with the present invention may further include associated dominant wavelengths within 15 nm or even within 5 nm of the specified colors and dominant wavelengths.

Replace paragraph [0058] with the following paragraph:

[0058] Still another embodiment of a LED array according to the present invention may include the plurality of LEDs comprising at least the following specified colors and falling within 25 nm of an associated dominant wavelength: violet 410 nm, indigo 445 nm, blue 475 nm, cyan 500 nm, aqua 520 nm, green 540 nm, lime 555 nm, yellow 570 nm, amber 590 nm, orange 610 nm, red-orange 635 nm, and deep red 665 nm. Other embodiments may further include associated dominant wavelengths within 15 nm or even 5 nm of the specified colors and dominant wavelengths. Of course, the proximity of the associated dominant wavelengths may be arbitrarily selected within the range of 5 nm to 25 nm, consistent with the present invention. The above described embodiments are merely exemplary.

Replace paragraph [0059] with the following paragraph:

[0059] Another embodiment of a LED array according to the present invention may include having each dominant wavelength separated from its nearest neighbor on either side by not more than a predefined separation distance. Any predefined distance within the range from about 10 nm to about 50 nm is consistent with embodiments of the present invention. For example and not by way of limitation, 20 nm, 30 nm, and 40 nm are embodiments of a predefined separation distance consistent with the present invention. According to yet another embodiment, the separation between the dominant

wavelengths may gradually increase~~s~~ away from either side of approximately 555 nm. Yet another embodiment of a LED array according to the present invention may further include LEDs with a dominant wavelength in the near-ultra-violet region defined from about 300 nm to about 400 nm.

Replace paragraph [0060] with the following paragraph:

[0060] Yet further embodiments of a LED array according to the present invention may include a plurality of LEDs numbering less than or equal to a predetermined number of LEDs. For example and not by way of limitation, the predetermined number of LEDs may be 100, 64, ~~36~~32, or 16 ~~LEDs~~ according to embodiments of the present invention. ~~In further e~~Embodiments of a LED array according to the present invention may further include each of the plurality of LEDs comprising a predetermined power rating. ~~f~~For example and not by way of limitation, the predetermined power rating may be at least 0.25, 0.5, or 1.0 Watts of power at full brightness according to embodiments of the present invention.

Insert the following new paragraphs between paragraphs [0061] and [0062].

[0061.1] FIG. 10 is a graphical representation of an exemplary area 1000 enclosed by plotting the output of each uniquely colored LED from an LED array according to the present invention on a CIE Chromaticity diagram as a point and connecting the points. The area 1000 covers approximately 75% of the total area 1002 defined within the curve of spectrally pure colors and an alychne of purple colors on the CIE Chromaticity diagram. It will be understood that this and other combinations of uniquely colored LEDs in an LED array may be used to achieve coverage of at least 75% of the total area 1002.

[0061.2] FIG. 11 is a graphical representation of an exemplary area 1100 enclosed by plotting the output of each uniquely colored LED from an LED array according to the present invention on a CIE Chromaticity diagram as a point and connecting the points. The area 1100 covers approximately 85% of the total area 1002 defined within the curve of spectrally pure colors and an alychne of purple colors on the CIE Chromaticity diagram. Again, it will be understood that this and other combinations of uniquely

colored LEDs in an LED array may be used to achieve coverage of at least 85% of the total area 1002.

[0061.3] FIG. 12 is a graphical representation of an area 1200 enclosed by plotting the output of each uniquely colored LED from an LED array according to the present invention on a CIE Chromaticity diagram as a point and connecting the points. The area 1200 covers approximately 95% of the total area 1002 defined within the curve of spectrally pure colors and an alychne of purple colors on the CIE Chromaticity diagram. Again, it will be understood that this and other combinations of uniquely colored LEDs in an LED array may be used to achieve coverage of at least 95% of the total area 1002.

Replace paragraph [0067] with the following paragraph:

[0067] The following is an exemplary test scenario in accordance with embodiments of method 800. The exemplary test scenario was applied to approximately seventy human test subjects ranging in age from fifteen to sixty-five years old. The human test subjects included lighting professionals as well as average consumers. The human test subjects were asked to provide quantitative ratings of color mixes in three~~,~~ different test sections comprising Tests I-III.

Replace paragraph [0070] with the following paragraph:

[0070] The results of Test I of the exemplary test scenario are contained in ~~the~~ Table 4 - Saturation Level, below. Table 4 includes a column showing the name of the test color, the light source used to produce the color, and the average saturation rating received for each color and source. The test colors of red, green, and blue were omitted, since for all possible combinations—RGB, High-Brightness, and All Ten Colors—the same LED colors would have been used. The light source with the highest average score (saturation) is shown for each color in bold.

Replace paragraph [0076] with the following paragraph:

[0076] The results for the whiteness test shown in Table 6 suggest that the High-Brightness LED mix appeared whiter than both the RGB mix and the All Colors mix of all

ten colors at all correlated color temperatures. The highest-rated white was the high-brightness mix at 7400 ~~degrees Kelvin~~.

Replace paragraph [0079] with the following paragraph:

[0079] A presently preferred embodiment of a color mix for a LED array consistent with the present invention may include seven colors of LEDs in ultra-high-brightness packages—comprising the six high-brightness colors used for testing and an additional high-brightness red LED. However, as the availability of additional high brightness LEDs covering additional portions of the visible spectrum increases, other preferred embodiments will become apparent. The ideal embodiment of a LED array of the present invention includes any suitable number of high-brightness, color LEDs sufficiently covering the visible spectrum to allow the user to accurately reproduce any desired dominant wavelength at any desired level of saturation and at a relative luminance level that is consistent with the distribution of spectral power in midday sunlight ~~(at approximately 6500K.)~~. The LED arrays, lighting fixtures and systems of the present invention appear to be superior to conventional lighting systems for reproducing visible light for a number of reasons. ~~including:~~ For example, the inventive lighting embodiments can produce more deeply saturated colors across the entire visible spectrum, generate richer whites with a greater range of realistic correlated color temperatures, generate fuller soft colors that are more appealing and more natural-looking, especially on skin tones, illuminate colored objects in a manner more similar to midday sunlight or other conventional white-light sources, and provide well--balanced color mixing with intuitive intensity levels at all colors.